AN INVASION OF AUSTRALIAN BLUE MOON AND BLUE TIGER BUTTERFLIES (LEPIDOPTERA: NYMPHALIDAE) IN NEW ZEALAND

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Abstract. Large numbers of two Australian butterflies, *Hypolimnas bolina nerina* and *Tirumala hamata hamata,* were reported in April-June 1995 in New Zealand, mostly in the north and west of the North Island. Meteorological evidence indicates that they probably arrived on 9-10 April from between about 24° and 32° S on Australia's east coast, and with a trans-Tasman passage time of 54-60 hours. A few specimens of other Australian butterflies *(Danaus chrysippus petilia, Cynthia kershawi, Junonia villida calybe* and possibly *Melanitis leda bankia* (Nymphalidae)) and moths *(Utetheisa pulchelloides vaga* (Arctiidae) and *Elygaea materna* (Noctuidae)) were also recorded over the same period.

Various organisms regularly arrive in New Zealand having been blown across the Tasman Sea from the Australian east coast. These include plant pathogens, fern spores, orchid seeds, and a variety of insects such as aphids, scale insects, fig wasps, moths and butterflies (Close et al. 1978; Ryan & Harris 1990; Gardner & Early in press). Immigrant Lepidoptera from Australia are frequently intercepted, sometimes in large numbers. Fox (1978) and Gibbs (1980) give good summaries of this phenomenon and review the literature. Which species arrives depends largely on the time of year, e.g., the painted lady (*Cynthia kershawi* McCoy) usually appears in spring (October-November) while the blue moon butterfly (*Hypolimnas bolina nerina* (F.)) makes it appearance only in autumn (April-May); these times coincide with periods of migratory movements within Australia. The blue moon is a sporadic visitor and occasional specimens appear in most years. On rare occasions they have arrived in large numbers and attracted considerable public attention. Two notable blue moon invasions have been documented: 720 specimens were observed in 1956 (Ramsay & Ordish 1966), and 108 specimens in 1971 (Ramsay 1971, 1973). Influxes of this size require several factors to coincide: the butterflies must be locally numerous and active in Australia; there must be appropriate meteorological conditions to get them airborne and keep them so while in transit; and they must settle out on New Zealand (Tomlinson 1973).

April 1995 seems to have been another of those times when the necessary conditions lined up to produce an invasion. The interesting thing about this influx was the additional presence of the Australian blue tiger, *Tirumala hamata hamata* (Macleay) rather than the blue moon alone. The purpose of this paper is to document the phenomenon, record localities where sightings were made, and to determine the origin of the specimens.

The records on which this paper is based derive from public enquiries to the Department of Conservation (Whangarei), the Auckland Museum, Landcare Research, MAF Lynfield (Auckland), Mr Peter Peckham (New Plymouth), the Museum of New Zealand (Wellington), Mr Jim Harding (Nelson), the Department of Conservation (Nelson) and the Otago Museum (Dunedin). No requests for information or sightings were made through the media, although a few smaller local newspapers *(Northland Age Courier,*

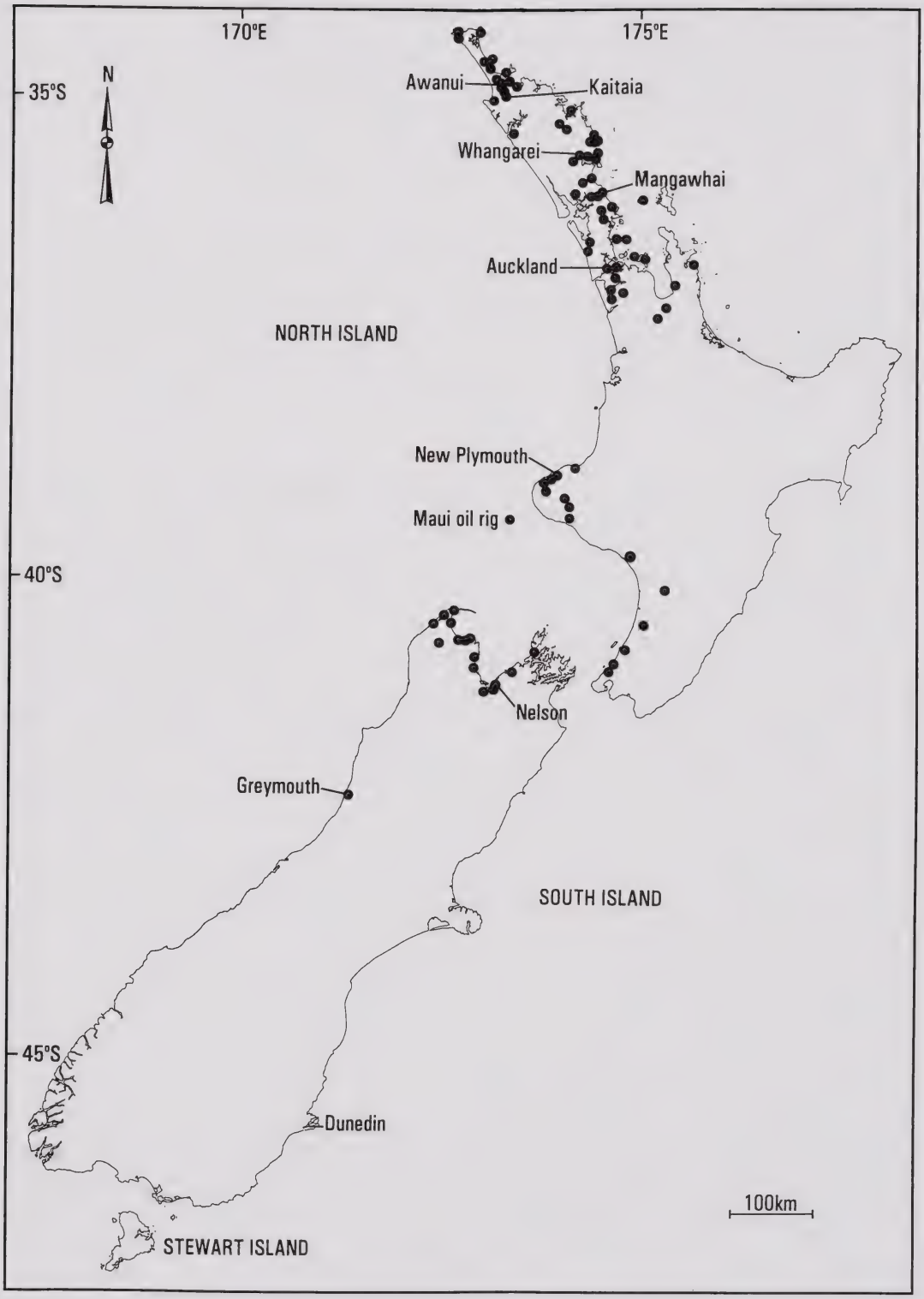


Fig. 1. Sightings of *H. bolina nerina* and/or *T. hamata hamata*, 9 April - 12 June 1995.

Northern Advocate, Mangawhai Memo, Taranaki Daily News, Observer, Nelson Evening Mail) ran articles and so stimulated local interest resulting in additional records. Most callers with enquiries about "strange and unusual butterflies" gave good descriptions that matched one of the two species, and several had consulted books and accurately identified them themselves. The sightings are supported by several voucher specimens and photographs in the Auckland Museum (AMNZ 1323-1328, 1506-1507, 1735), the Museum of New Zealand and the Otago Museum.

RECORDS

The first two specimens we are aware of were observed on Sunday 9 April 1995. The first, a blue tiger, was collected at about 1330 h 5 km west of Kaitaia, Northland (AMNZ 1506). The second, a blue moon, was seen in the evening on the Maui oil rig which is approximately 40 km off the Taranaki coast from Opunake, and almost 500 km south of Kaitaia. In total, there were 103 sightings of blue moons and 57 of blue tigers representing at least 142 and 67 specimens respectively. Several observers reported seeing groups of "several", "dozens", "lots" and "a flock", and groups often contained both species. Most (75%) sightings occurred over the period 12-22 April which included the Easter holiday; sporadic sightings continued until 12 June.

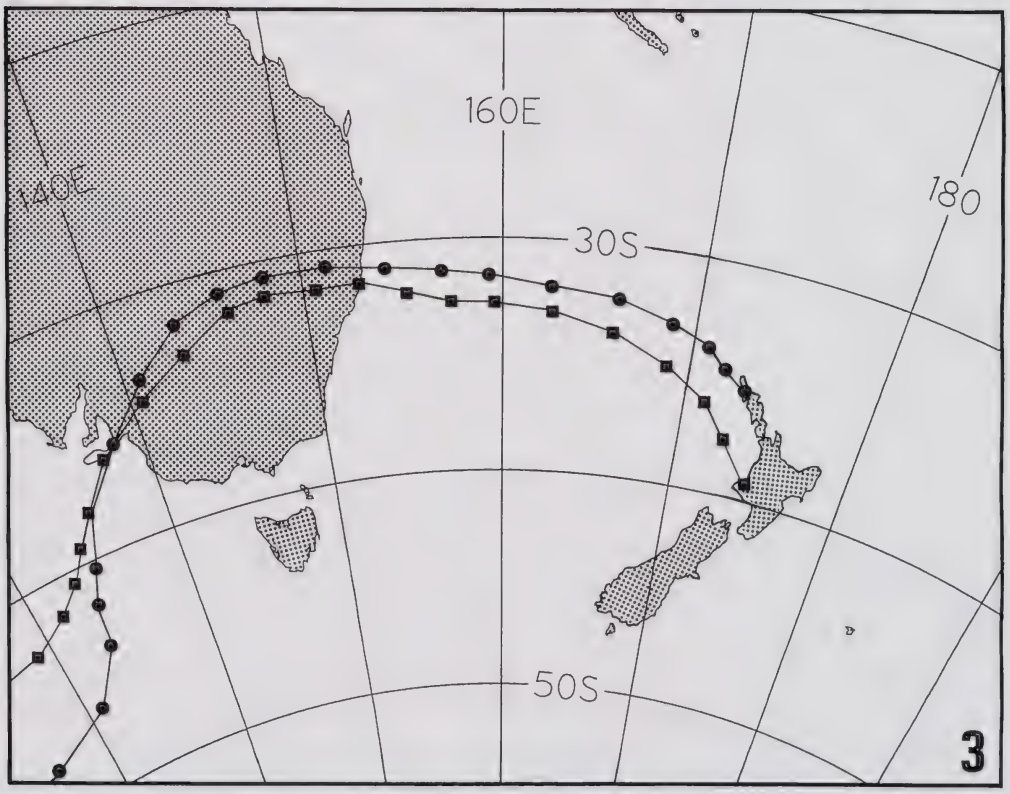
Most records came from Northland (Fig. 1). Very few butterflies were seen around metropolitan Auckland. Considerable numbers were also recorded from Taranaki, Manawatu, the Kapiti Coast, and Nelson. The southernmost blue moon record came from Greymouth. A detailed list of locality records and dates is available on request. Their distribution is shown in Fig. 1 where the two species are not differentiated since both were often found together.

As with previous instances of immigrant butterflies, many specimens were in near perfect condition. Several observers reported them feeding on flowers of *Lantana* sp., *Grevillea* sp., *Hebe* sp., *Aster novi-belgii* (Michaelmas daisy) and *Solanum muricatum* (pepino).

In addition to the blue moon and blue tiger butterflies, six other Australian Lepidoptera were reported and are listed in Table1. Although most of the butterflies were seen in the North Island, two of the three records of the fruit sucking moth (*Elygea materna*) came from Dunedin and Stewart Island respectively, and one of the three lesser wanderer butterflies (*Danaus chrysippus petilia*) also came from Dunedin. The Dunedin records predate the earliest blue moon and blue tiger records by 2-3 days.

DISCUSSION

This influx of foreign butterflies is the third recorded occasion involving large numbers of the blue moon, but it differed from the previous two in that it also included the largest number of blue tigers ever seen in New Zealand. The latter species is one of our rarest Australian butterfly visitors, only four specimens being known by Gibbs (1980). Numbers of each species in Table 1 should be treated with caution. Group sightings indicate that there were more present than those listed in Table 1. In some localities many butterflies apparently remained in the area over several days (e.g., Mangawhai, Northland), so repeated sightings of the same individuals were likely. Their main value is to indicate the relative abundance of the species, and that butterflies arrived in a significant influx rather than their usual sporadic appearance. It is inappropriate to compare numbers with those recorded by Ramsay & Ordish (1966) and Ramsay (1971, 1973) from the 1956 and



Figs 2-3. Trajectory plots of air movement at 1000 m. 2. Arrival at 1200 UTC Sunday 9 April 1995. 3. Arrival at 0000 UTC Monday 10 April 1995. ● = trajectory for arrival at Kaitaia, ■ = trajectory for arrival at New Plymouth. Points on each trajectory are 6 hours apart.

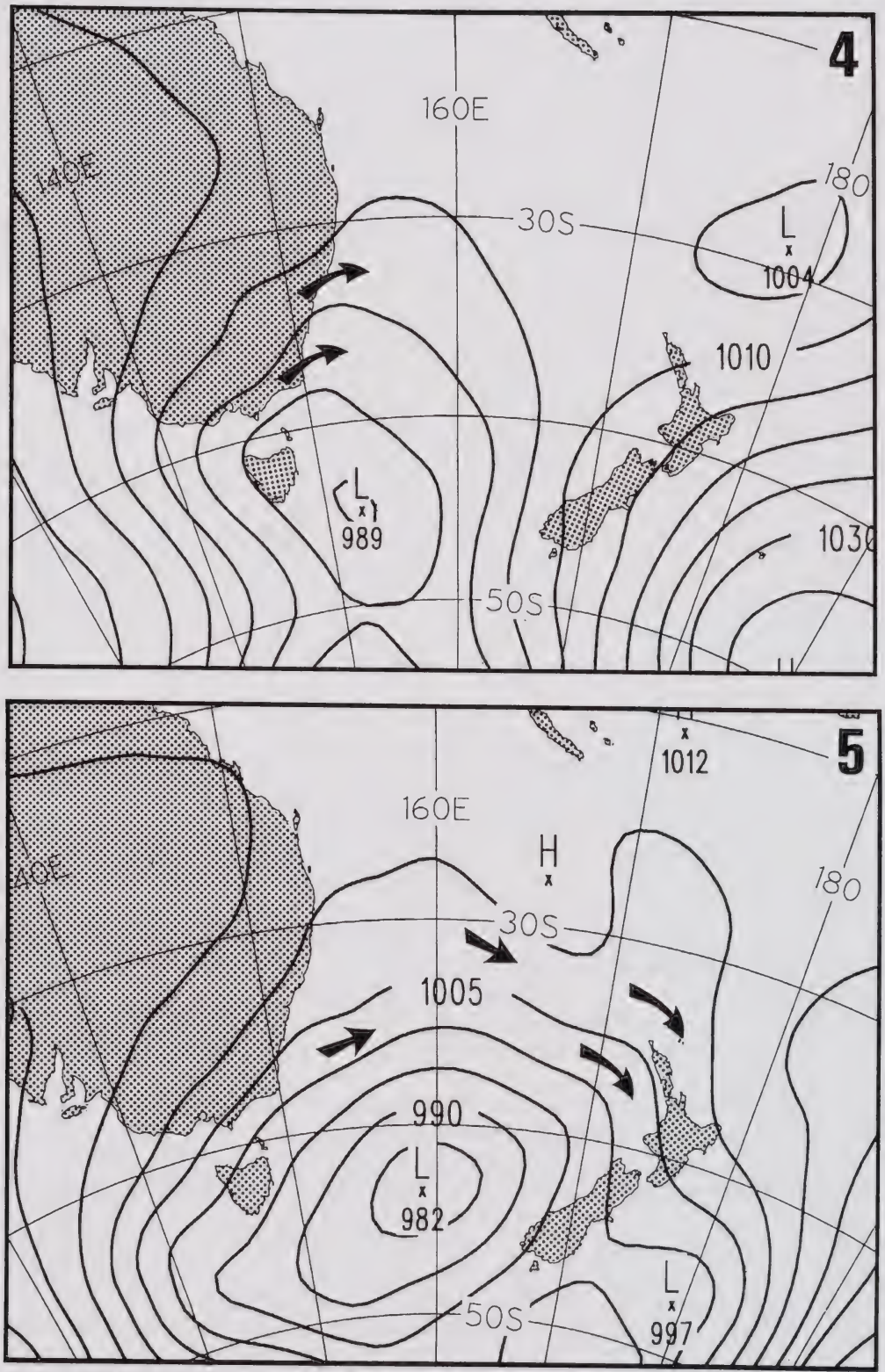
Table 1. Records of Australian Lepidoptera in New Zealand, April-June 1995 (* = unconfirmed record).

Species	Common name	Number of specimens	Locality
Hypolimnas nerina bolina (Fabricius)	blue moon butterfly	142	North & South Is; see Fig. 1
Tirumala hamata hamata (Macleay)	blue tiger butterfly	67	North & South Is; see Fig. 1
Danaus chrysippus petilia (Stoll)	lesser wanderer	3	Northland (Awanui, Waima), Dunedin
Cynthia kershawi McCoy	painted lady	1	New Plymouth
Junonia villida calybe (Godart)	meadow argus	1	New Plymouth
**Melanitis leda bankia* (Fabricius)	evening brown	1	New Plymouth
Utetheisa pulchelloides vaga Jordan	crimson speckled footman	2	New Plymouth, Wellington
Elygaea materna (L.)	fruit sucking moth	3	Northland (Awanui), Dunedin, Stewart I.

1971 invasions, respectively, because of differences in degree of publicity and requests for sightings.

Where did they come from? All species in Table 1 are widely distributed in the Indo- Australian and Pacific regions, some reaching up into the Oriental region. *Tirumala hamata* is found from Java, Sulawesi and the Philippines eastward through the southern Moluccas, New Guinea and Solomons to Fiji, Tonga and Samoa, and southward to northern and eastern Australia (Ackery & Vane-Wright 1984). Several morphs with localised distributions within this range are recognised, and the one concerned with here, *T. hamata hamata*, is restricted to Australia, the islands of Torres Strait and New Guinea. Similarly, *H. bolina* with its constituent subspecies is distributed from India and Taiwan, through south-east Asia to the islands of the central Pacific (Fiji, Samoa, Tonga); the subspecies recorded here, *H. bolina nerina*, is restricted to New Guinea, northern and eastern Australia, the Bismarck Archipelago, Solomons, Vanuatu and Norfolk Island (Common & Waterhouse 1972).

Analysis of weather maps and back-plotted airflow trajectories is required to narrow down the butterflies' likely geographical origin. On 9 April, a period of northeasterly winds over much of the North Island was replaced by a prolonged period of northwesterlies about a depression located to the southwest of New Zealand in the Tasman Sea. The NW wind was already established in Kaitaia at the time the first butterfly was collected (J. Bond, pers. comm.). Speculation as to the butterflies' possible origin in the Pacific islands on account of the NE wind flow onto New Zealand for the few days preceding their arrival can be dismissed on two grounds. Firstly, they are not the representative subspecies/ distinctive populations that are found on the Pacific islands. Secondly, although trajectories ending over the North Island before the 9th seem to originate from the east, there is no meteorological evidence that their origin is in the tropics. Rather, they appear to originate around 40° S, spiralling counterclockwise before arriving over New Zealand in an ENE current (M.R. Sinclair, in litt.).



Figs 4-5. Weather maps for 0000 UTC. Arrows show wind direction; numbers are mean sea level pressure (hPa). 4. Friday 7 April 1995, butterflies will have left Australia by now. 5. Sunday 9 April 1995, approximate time of arrival of first butterfly.

Back-plotted trajectories for arrival in Northland (Kaitaia) and Taranaki (New Plymouth) at midday local time (0000 UTC) on 9 April 1995 for the 1000 m level do not give a clear indication as to the butterflies' point of origin, perhaps due to the changing wind systems and some of the assumptions and errors involved in trajectory calculation (see Tomlinson 1973). Trajectories ending 12 hours later (1200 UTC on the 9th, Fig. 2) make some sense for a Kaitaia arrival and indicate a southern Queensland origin, but not for a New Plymouth arrival. By 0000 UTC on 10 April (Fig. 3) both trajectories suggest an Australian origin and a rapid transit of about 54-60 hours of the Tasman Sea. Fig. 2's Kaitaia trajectory indicates departure between 1800 UTC on 6 April and 0000 UTC on the 7th (0400-1000 h Australian Eastern Standard Time, 7 April). Around this time, much of the Australian east coast experienced southwesterly winds (Fig. 4) which could have displaced the butterflies northeastwards out to sea, then spiralled around clockwise to bring them to New Zealand on a northwesterly wind (Fig. 5).

Comparison of the trajectories in Figs 2 and 3 is interesting because although the earlier one for Kaitaia (Fig. 2) indicates an origin from over the Queensland coast near 25° S, the later one (Fig. 3) is from northern New South Wales, just south of 30° S. These trajectory calculations are based on a parcel of air at 1000 m. It is difficult to know at what altitude butterflies cross the Tasman, but it may well be at much lower levels, from 0-100 m. Gibbs (1980) argued that the distribution of butterflies following an invasion favours coastal locations to such an extent that it is highly suggestive of a sea-level approach. The observation of a blue moon on the Maui oil rig, some 40 km offshore, lends credence to this idea. Updraughts during the NW winds in this study were slight (around 200 mm/s, M.R. Sinclair, pers. comm.) and both the blue moon and blue tiger, which are strong fliers, would be able to maintain their vertical position and not be carried passively to great altitudes during passage. Airflow at lower altitudes, e.g. around 100 m, would be slightly weaker than at 1000 m and turned slightly towards lower pressure, making the current more northerly (M.R. Sinclair, in litt.). This would result in both a slightly longer transit time, and make the butterflies' point of origin at a slightly lower latitude.

The precise geographical origin of these immigrant Lepidoptera cannot be pinpointed but it appears to be somewhere on Australia's east coast between about 24° S and 32° S, i.e. between Bundaberg (southern Queensland) and Port Macquarie (northern New South Wales). The moths and other butterflies listed in Table 1 are also found in this region (Common 1990; Common & Waterhouse 1972). Except for the two specimens recorded from Dunedin (see below), all were probably displaced by a single meteorological event (e.g., a cold front as it swept up the Australian coast) but may have continued to arrive in New Zealand on persistent NW winds over a period of perhaps 24 hours.

The single specimens of *E. materna* and *D. chrysippus petilia* from Dunedin must be excluded from the above invasion of Australian Lepidoptera. They were sighted on 6 and 7 April respectively, predating the first specimens of the blue moon and blue tiger invasion by up to three days. Northeast winds prevailed at that time so they cannot possibly have arrived on the same weather system as the other butterflies. Their origin remains unknown. They may have arrived from Australia on an earlier northwesterly airflow but were not detected until some time after arrival. Other lesser wanderers predating the invasion were found near Auckland (JWE unpubl.).

Suitable host plants for oviposition and larval development of the blue moon and blue tiger are present in New Zealand (see Gibbs 1980), but there is no evidence of even temporary establishment. They are essentially tropical/subtropical species and, despite their repeated appearance here (probably over the last 2 million years), are likely to

remain occasional/regular immigrants and not become permanent members of our small butterfly fauna.

Notes Added in Proof

1. Dr Courtney Smithers (Research Associate, Australian Museum, Sydney) informed JWE (in litt., 15 Oct 1995) that hundreds of blue tigers arrived on Norfolk Island on 9 April 1995, the same day that the first butterflies of the New Zealand invasion were seen (see Smithers, C.N. The first record of *Tirumala hamata hamata* (W.S. Macleay) (Lepidoptera: Nymphalidae) on Norfolk Island. *Norfolk Nature Notes,* July 1995, pp 395-396). Dr Smithers (in litt.) also reported hearing of a migrating group of *T. hamata.* They were observed on 7 April 1995 from a yacht at sea approximately 125 km south of Bundaberg, Queensland, where a dense population was reported flying east over a 7-9 km front. It is impossible to know whether these were the same butterflies that eventually arrived in Norfolk Island and/or New Zealand, but this sighting confirms that migrating butterflies cross the Tasman Sea at low altitudes rather than by rapid passage in high altitude air flows.
2. A single *T. hamata hamata* was taken in April from the eastern Bay of Plenty (Whanarua Bay, 37° 41'S, 177° 47'E) and a blue moon from Hawkes Bay (Te Awanga, 39° 38'S, 176° 59'E). These records represent a considerable eastward extension of the range of New Zealand interceptions.

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